# Appendix E

# Groundwater and Surface Water Monitoring

# 1.0 Groundwater and Surface Water Monitoring

## 1.1 Groundwater

The designated groundwater use classification at the COU is surface water protection. This is based on the fact that groundwater contaminated by historical site operations emerges to surface water prior to exiting the COU. The numeric values for measuring potential effects of contaminated groundwater on surface water quality are the surface water standards in RFLMA Attachment 2, Table 1. It should be noted that the CAD/ROD and RFLMA incorporated some MCL values as surface water standards, in cases where surface water standards were not available.

The groundwater monitoring network includes four types of monitoring wells: AOC, Sentinel, Evaluation, and RCRA. The AOC wells provide data directly relevant to groundwater RAO 1; the Sentinel wells provide data directly relevant to groundwater RAO 2 and soil RAO 1 and are discussed in Section 6.1.2. The RCRA wells are directly related to the remedies implemented at the PLF and OLF and are discussed in Sections 6.1.4.1 and 6.1.4.2, respectively. The data collected during this FYR period at the Evaluation wells is summarized in this appendix.

The remedy in the CAD/ROD included the operation and maintenance of four groundwater collection and treatment systems (DOE 2006). As a result of technology improvements and optimization during this FYR period, the number of treatment system was reduced to three, although there are still four groundwater collection systems. The reconfiguration of the treatment systems is summarized in Section 6.1.4.3 and discussed in detail in the Site annual reports. Monitoring of treatment system influent, effluent, and surface water locations associated with the treatment systems is summarized in this appendix.

### 1.1.1 Evaluation Wells

Evaluation wells are typically located within plumes or near plume source areas, or in the interior of the COU (Figure B-1). There are 42 Evaluation wells within the COU that are sampled every 2 years (biennially) in accordance with RFLMA. The primary purpose of these wells is to determine when monitoring can be modified or discontinued. Data from these wells may also be used to support other objectives, such as providing input to groundwater modeling efforts, modification of groundwater monitoring and/or treatment requirements, or evaluation of changing contaminant conditions as indicated by downgradient AOC or Sentinel wells.

The RFLMA Attachment 2 decision logic flowchart Figure 9, "Evaluation Wells" (Appendix B), is relevant to Evaluation well data. In general, groundwater quality within plumes that were identified and characterized through the decades of pre-closure groundwater monitoring at the Site has not changed much since site closure. As anticipated, due to their location within or adjacent to groundwater contaminant plumes, groundwater did not meet surface water standards at most Evaluation wells during this FYR period. Thus, continued monitoring of Evaluation wells is necessary to determine when groundwater is of sufficient quality to remove institutional control use restrictions and monitoring may cease. Discussion of plume-specific Evaluation well data may be found in the Site annual reports for 2012, 2014, and 2016 (DOE 2013; 2015; 2017).

During this FYR period, additional, non-routine samples from Evaluation wells were collected following the heavy precipitation event in 2013 and the wet conditions in 2015. The Rocky Flats annual reports for 2013 and 2015 provide an evaluation of these sample results (DOE 2014; 2016). Despite the relatively extreme weather events, groundwater quality in the COU in 2013 and 2015 was largely consistent with data reported in prior years.

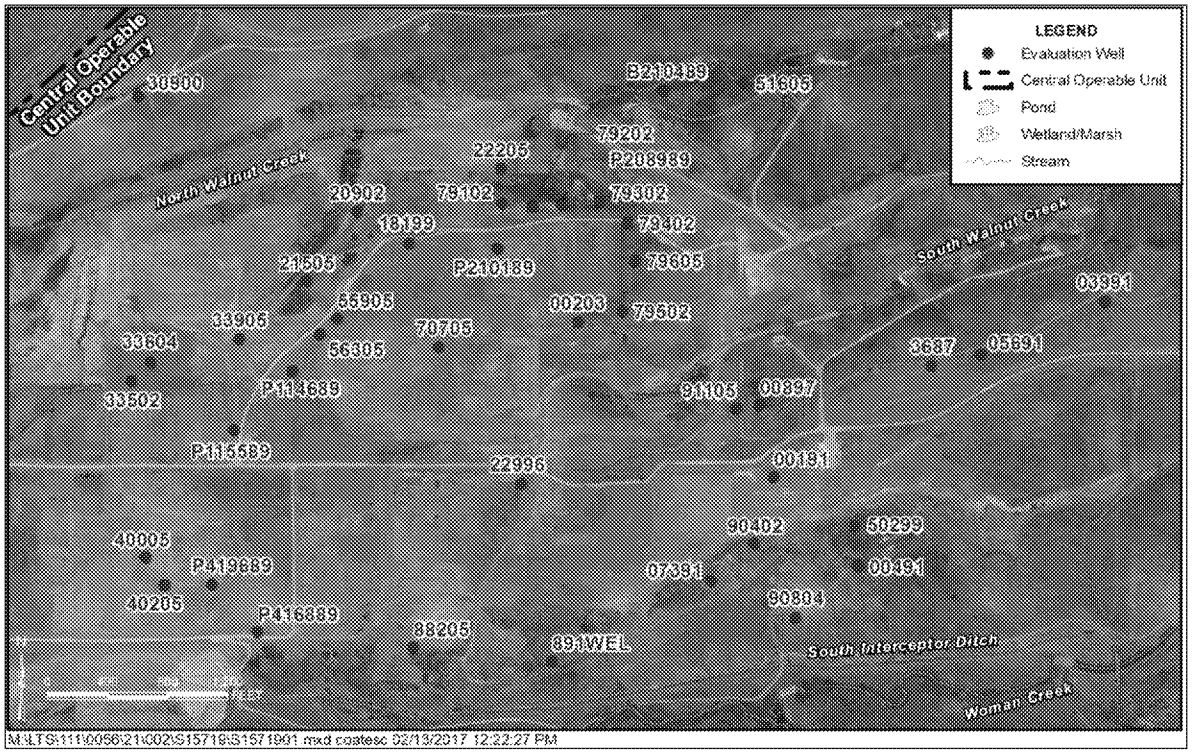



*Figure E-1. Evaluation Well Locations*

### 1.1.2 Groundwater Treatment System Monitoring

The locations of the groundwater treatment systems in the COU are shown on Figure B-2. The groundwater treatment systems are designed to reduce target contaminant concentrations in groundwater and contaminant load to surface water. Each groundwater treatment system is monitored, at a minimum, for untreated influent and treated effluent, and for impacts to surface water downstream of each subsurface effluent discharge point. Evaluation of groundwater treatment system performance determines whether (1) influent water quality indicates that treatment is still necessary, (2) effluent water quality indicates that system maintenance is required, and (3) surface water quality suggests impacts from inadequate treatment of influent. The RFLMA Attachment 2 decision logic flowchart Figure 11, "Groundwater Treatment Systems" (Appendix B), is relevant to the treatment systems monitoring data.

The groundwater treatment systems are being properly maintained and operated, but some constituents in system effluent have not consistently met RFLMA standards. This triggers RFLMA consultation to determine if any mitigating actions should be implemented. The actions resulting from the RFLMA consultative process during this FYR period have focused on optimizing treatment capabilities of the systems and are summarized in Section 6.1.4.3.

### *1.1.2.1 PLFTS*

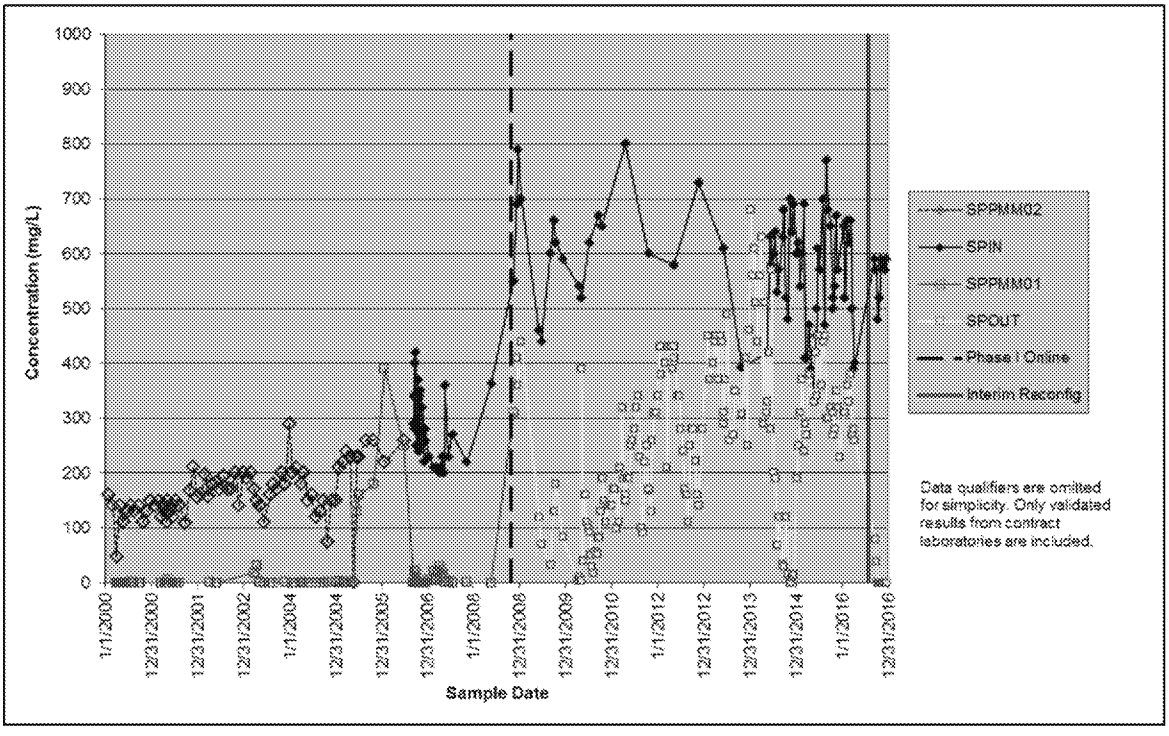
The PLFTS was installed in 2005 and consists of a gravity-fed, passive system designed to treat groundwater and seep water for VOCs. In contrast to the other Site treatment systems, there have been no alterations to this system since it was installed and no opportunities for optimization have been identified. Operation and monitoring of the PLFTS during this FYR period is discussed in Section 6.1.4.1 and is not repeated herein. A yearly account of sampling data and evaluation of the PLFTS may be found in the Site annual reports.

### *1.1.2.2 SPPTS*

The SPPTS was installed in 1999 and was designed to treat groundwater contaminated with nitrate and uranium from the Solar Ponds source area. Throughout this FYR period, work has progressed in an attempt to refine treatment at the SPPTS and identify the most appropriate and efficient long-term system configuration. Optimization of this treatment system is summarized in Section 6.1.4.3. Evaluation and testing of system performance is ongoing and is planned to continue into the next FYR period. In conjunction with treatment system testing, additional non-routine monitoring samples of the influent, effluent, and from the downstream surface-water location GS13 have been collected.

Figures E-3 and E-4 present nitrate and uranium data, respectively, for influent and effluent monitoring at the SPPTS from 2000 through 2016. While reduction of nitrate and uranium loads to surface water from the Solar Ponds plume has continued throughout this FYR period, the reduction of constituent concentrations to below surface water standards has not consistently been achieved. For both nitrate and uranium, routine samples of SPPTS influent and effluent have been above RFLMA standards during this FYR period, as have some samples from surface water monitoring location GS13. An evaluation of the Walnut Creek drainage system concluded that approximately 5 percent of the uranium load measured at GS13 and approximately 20 percent of the nitrate load (prior to system reconfiguration), comes from SPPTS effluent (Wright Water Engineers 2015). This suggests that effluent from the SPPTS does not have a large impact on uranium concentrations detected in North Walnut Creek at GS13 or WALPOC. While the nitrate standard at WALPOC has been continuously met in surface water samples, uranium concentrations have exceeded the RFLMA standard intermittently throughout this FYR period. The uranium 12-month rolling average at WALPOC exceeded the standard for a four-month period in 2014/2015 and currently exceeds the standard as of December 2016. Uranium conditions at WALPOC are discussed further in Section 6.1.3.1. Based on the Walnut Creek evaluation, however, the concentrations of uranium at WALPOC do not appear to be a direct result of SPPTS operations.

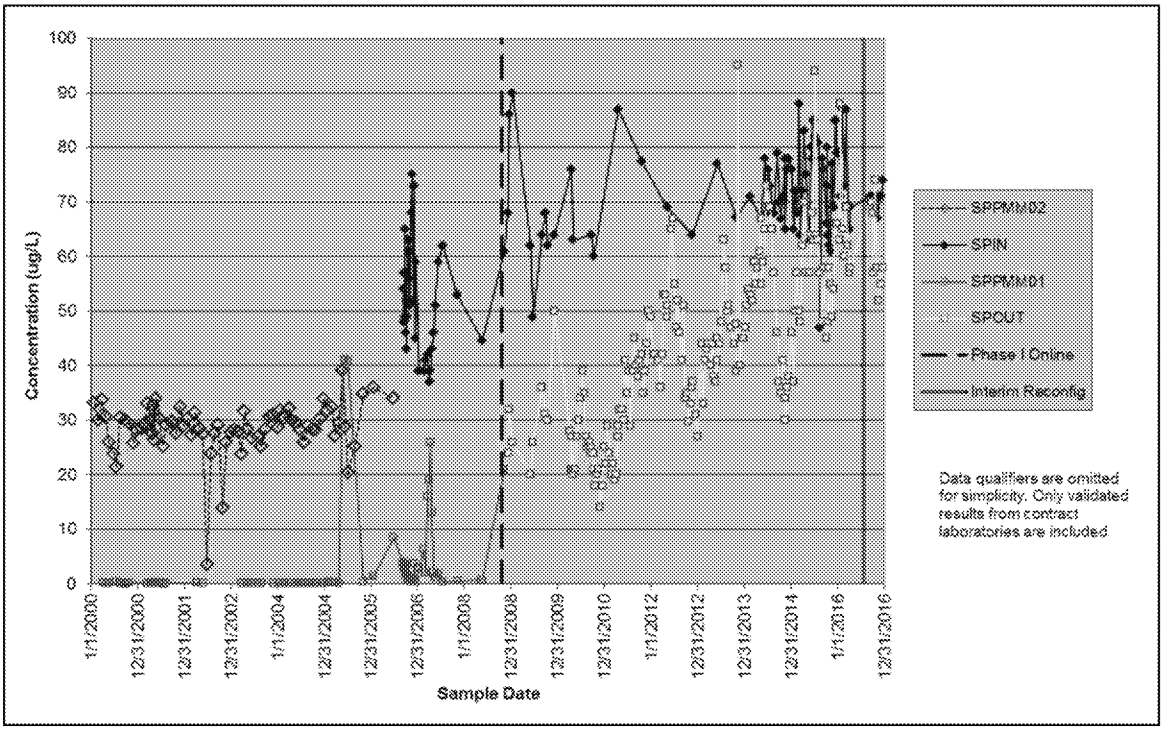
In general, effluent conditions at the SPPTS did not show improvement during this FYR period until completion of the SPPTS reconfiguration project in late 2016. Since reconfiguration completion, nitrate concentrations in SPPTS effluent have consistently been below RFLMA standards. The results of uranium treatment to date have proven less encouraging, however efforts to identify an effective long-term system configuration continue through the RFLMA consultative process.




**Notes:** SPPMM02/SPIN = system influent; SPPMM01/SPOUT = system effluent; Interim Reconfig indicates when the 2016 reconfiguration was completed. Phase I Online = date when Phase I upgrades were completed.

*Figure E-3. Total Nitrate in SPPTS Influent and Effluent (2000-2016)*


*Figure E-2. Surface Water Performance Monitoring Locations*




**Notes:** SPPMM02/SPIN = system influent; SPPMM01/SPOUT = system effluent; Interim Reconfig = date when the 2016 reconfiguration was completed. Phase I Online = date when Phase I upgrades were completed.

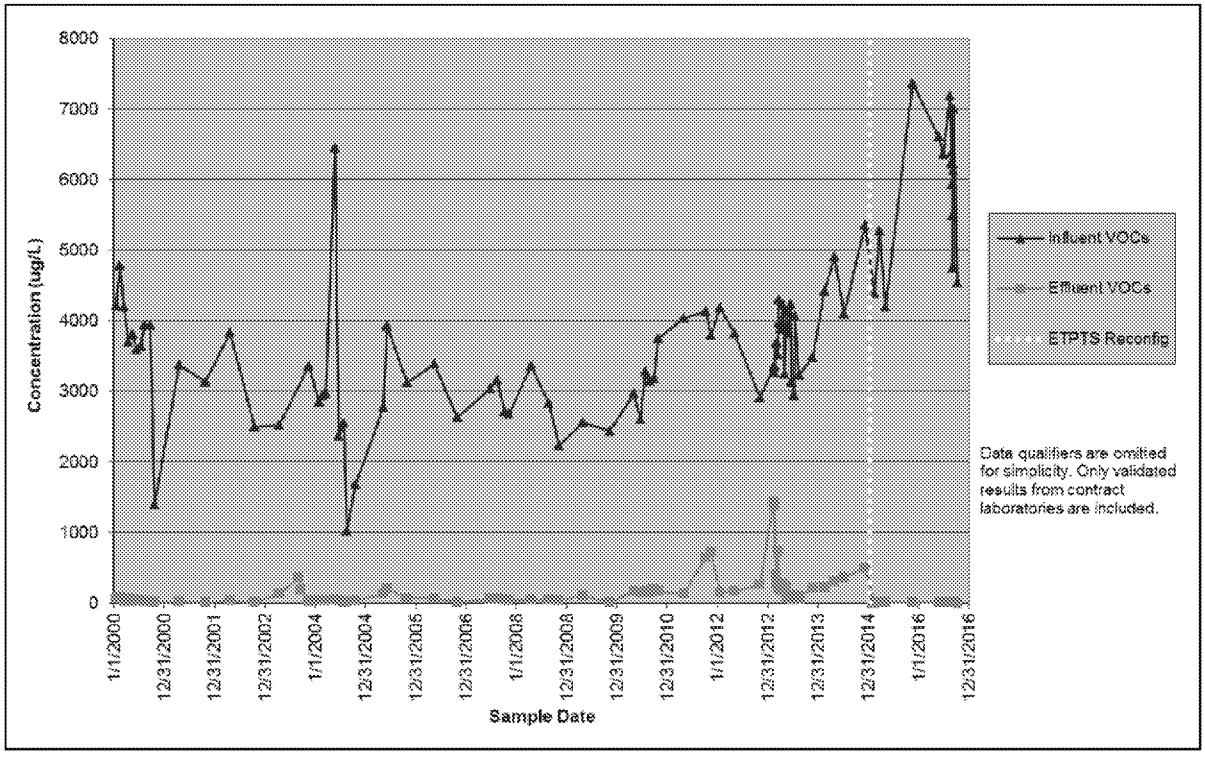
*Figure E-4. Total Uranium in SPPTS Influent and Effluent (2000-2016)*

### *1.1.2.3 ETPTS*

The ETPTS was designed to treat groundwater contaminated with VOCs from the East Trenches source area and was installed in 1999. Optimization of this treatment system is summarized in Section 6.1.4.3.

Figure E-5 presents total VOC data for influent and effluent monitoring at the ETPTS from 2000 through 2016. Throughout this FYR period, several VOCs exceeded RFLMA standards in both the influent and effluent. Since completion of the ETPTS reconfiguration in early 2015, however, treatment effectiveness is much improved and effluent concentrations of VOCs are almost always below RFLMA standards. Of the 12 effluent samples collected since the reconfiguration project was completed, concentrations of TCE exceeded the RFLMA standard in 3 samples (the highest concentration of TCE in ETPTS treated effluent since the reconfiguration was 3.3 ug/L; the standard is 2.5 ug/L). Figure E-5 illustrates that the ETPTS has been effective, and is now much more effective, in reducing contaminant concentrations in groundwater treated by the system and reducing contaminant load to surface water. The reconfiguration of the system to include an air stripper has significantly improved the reduction of contaminant concentrations in ETPTS effluent.

The surface water performance monitoring location associated with the ETPTS is POM2 (Figure E-2). Low concentrations of VOCs were occasionally detected in surface water samples from this location collected during this FYR period. However, no VOCs have ever exceeded their respective RFLMA standards at this location.




**Notes:** "ETPTS Reconfig" refers to when the ETPTS Reconfiguration Project to install a commercial air stripper was completed. Data in late 2016 represent treatment of combined MSPTS+ETPTS influent.

*Figure E-5. Total Detected VOCs in ETPTS Influent and Effluent*

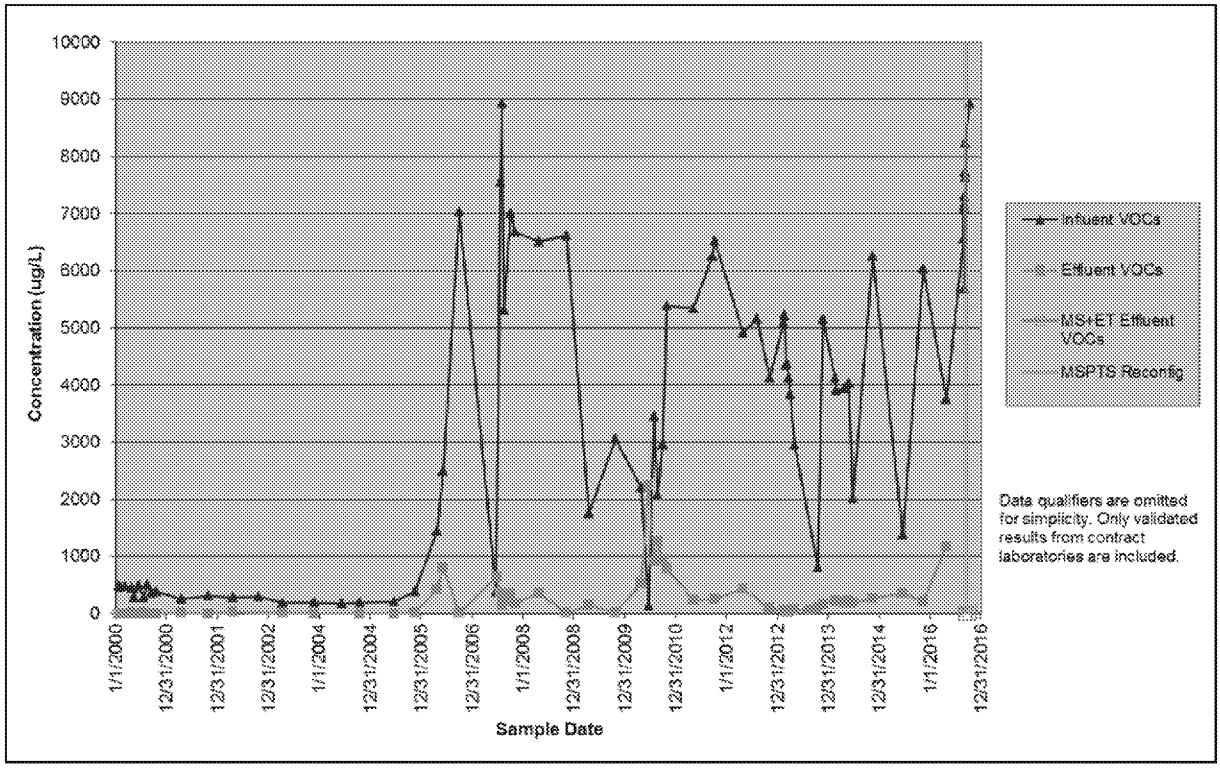
### *1.1.2.4 MSPTS*

The MSPTS was designed to treat groundwater contaminated with VOCs from the Mound source area and was installed in 1998. Groundwater impacted by residual contaminants in the nearby Oil Burn Pit #2 (OBP#2) area was directed to this treatment system beginning in 2005. Optimization of this treatment system is summarized in Section 6.1.4.3.

Figure E-6 presents total VOC data for influent and effluent monitoring at the MSPTS from 2000 through 2016. Throughout this FYR period, several VOCs have exceeded RFLMA standards in both the influent and effluent. In late 2016, reconfiguration of the MSPTS was completed and groundwater from the Mound plume was routed to the ETPTS for treatment (CR 2015-04). The reconfiguration resulted in a significant improvement in treatment of VOCs originating at the Mound and OBP#2 areas. The treatment of TCE has posed the greatest challenge to the MSPTS since operations began. Following system reconfiguration, however, TCE in system effluent has

consistently been below the RFLMA standard. Figure E-6 illustrates that throughout the operating life of the MSPTS, the system was effective in reducing contaminant concentrations in groundwater treated by the system and in reducing contaminant load to surface water. The last data points shown on Figure E-6 for MSPTS effluent represent the treatment of combined MSPTS and ETPTS influent, and met all RFLMA standards.

For the majority of this FYR period, the surface water performance monitoring location associated with the MSPTS was GS10, located in the South Walnut Creek drainage (Figure E-2). No VOCs were detected above RFLMA standards at GS10 in 2012 or 2013; TCE was detected above the RFLMA standard at this location in 2014, 2015, and 2016. The high groundwater flows resulting from heavy precipitation in 2013 and 2015, and the consequentially reduced residence time for influent within the reactive media in the MPSTS, are factors in these TCE exceedances. Since treatment of Mound and OBP#2 plume groundwater no longer occurs at the MSPTS, surface water location GS10 is no longer used to evaluate treatment system performance. This role is now filled by POM2, the surface water performance location assigned to the ETPTS, as discussed below. The GS10 location, however, continues to serve as a POE in the surface water monitoring network in the COU.




**Notes:** VOC data shown represent arithmetic sums of all validated detections at locations MOUND R1-0 (influent) and MOUND R2-E (effluent) until the latter location was eliminated in late 2016. "MSPTS Reconfig" refers to the date when the MSPTS Reconfiguration Project was completed, routing MSPTS influent to the ETPTS for treatment. Data in late 2016 represent treatment of combined MSPTS+ETPTS influent.

*Figure E-6. Total VOCs in MSPTS Influent and Effluent, 2000 Through 2016*

## 1.2 Surface Water

The applicable surface water uses are consistent with the following Colorado surface water use classifications:

- Water Supply
- Aquatic Life—Warm 2
- Agriculture
- Recreation N (North Walnut Creek, South Walnut Creek, Pond C-2)
- Recreation E (Woman Creek)

The surface water monitoring network includes three types of locations: points of compliance (POCs), points of evaluation (POEs), and performance monitoring locations. Evaluation of data collected at the POCs during this FYR period are directly relevant to surface water RAO 1 and are discussed in Section 6.1.2. This section summarizes data collected during this FYR period at the POEs and performance monitoring locations.

### 1.2.1 Points of Evaluation

The POEs (locations GS10, SW027, and SW093) are located upstream of the POCs (Figure 2) and provide an early indication of the quality of surface water flowing toward the POCs. The RFLMA Attachment 2 decision logic flowchart Figure 6, "Points of Evaluation" (Appendix B), are relevant to data collected at these locations. During this FYR period, there were periodic exceedances of the surface water quality standards for actinides and uranium at GS10 and SW027. The exceedances of 12-month rolling averages for U, Am, and Pu at GS10 and Am and Pu at SW027 resulted in reportable conditions for these locations. There were no reportable conditions during this review period for SW093.

#### *1.2.1.1 GS10*

Surface water monitoring location GS10 is the POE in South Walnut Creek upstream of WALPOC. This location monitors surface water from the drainage area for a major portion of the former industrial area. The monitoring equipment at GS10 was upgraded and relocated in 2013 to avoid the potential for monitoring interruptions due to the movement of an adjacent hillside slump. The new location is approximately 40 feet east of its original location (CR 2013-01).

***Uranium.*** The 12-month rolling average for U at GS10 (18.8 µg/L) exceeded the RFLMA standard of 16.8 µg/L at the end of April 2011 (CR 2011-04). The plan to evaluate this reportable condition included the collection of surface water and groundwater samples from locations upstream and downstream of GS10. Based on these results, additional evaluation of this condition was determined necessary (CR 2011-05). The 12-month rolling average for uranium at GS10 did not fall below the RFLMA standard until March 2013. The average remained below the standard until the end of May, when the standard was again exceeded. In September 2013, the 12-month rolling average for uranium (14.6 µg/L) fell below the RFLMA standard and

remained below the standard through the end of this FYR period. Figure E-7 presents the 12-month rolling average data for total U at GS10 from 2005 – 2016.

From the initial reportable condition at GS10 in April 2011 until late 2013, U concentrations downstream of GS10 at WALPOC were below the RFLMA standard. In December 2013, the 30-day average U concentration (16.9 µg/L) at WALPOC exceeded the standard (16.8 µg/L) and became a reportable condition (CR 2014-05). Other reportable conditions for U occurred at WALPOC in October 2014 (CR 2015-01), January 2016 (CR 2016-01), and December 2016 (CR 2017-02). The 12-month rolling averages for WALPOC from 2011 through the end of 2016 are shown in Figure 5. Data collected prior to mid-2015 to evaluate these reportable conditions were included in extensive evaluation of conditions in the Walnut Creek drainage system. The results of this evaluation and additional discussion of the reportable conditions at WALPOC are presented in Section 6.1.3.1.

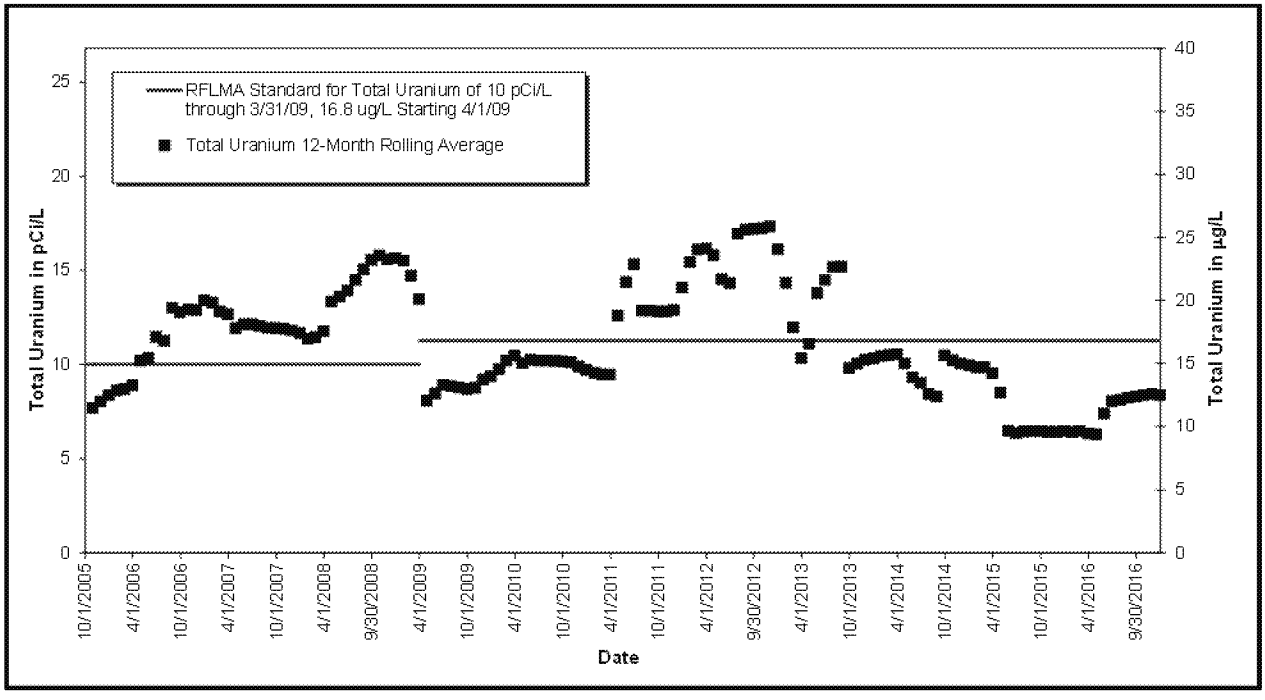



*Figure E-7. Volume-Weighted 12-Month Rolling Average Total U Concentrations at GS10: Post-Closure Period*

***Americium and Plutonium.*** In August 2011, the 12-month rolling average for Am at GS10 (0.21 pCi/L) exceeded the RFLMA standard of 0.15 pCi/L, resulting in a reportable condition at GS10 (CR 2011-08). The plan to evaluate this reportable condition included the inspection of upstream areas for seeps and indications of soil erosion, the collection of surface water and seep samples from upstream and downstream locations, and the review of historical data. At the time, the Pu concentration at GS10 was not reportable, but since Pu and Am are found together and behave similarly in the environment, the evaluation plan for the Am reportable condition included sample analyses for both Am and Pu. In May 2012, the 12-month rolling average for Pu at location GS10 (0.17 pCi/L) exceeded the RFLMA standard of 0.15 pCi/L and became a

reportable condition (add email notification reference). Figure E-8 presents the 12-month rolling averages for Am and Pu from 2005 through 2016 .

The evaluation of the Am and Pu reportable conditions focused on assessment of the potential transport mechanisms for these radionuclides, namely soil erosion and transport in water via various mechanisms. Inspection of the GS10 drainage did not identify any obvious soil erosion that could potentially impact surface water quality. This observation, coupled with the fact that the elevated Pu/Am results for GS10 were obtained during relatively dry conditions at the site, suggested that soil/sediment transport was not a primary contributor to the reportable condition at GS10. Sampling of several seeps identified upstream of GS10 (DOE 2014) suggested that seeps may be contributing some Pu/Am to surface water at GS10, however, seep contributions alone could not adequately explain the measured Pu/Am concentrations at GS10. Evaluation of data for colloidal transport did not provide additional insight into the reportable condition evaluation at GS10.

Mitigating actions were not required to address these reportable conditions because downstream conditions remained well below the RFLMA standards for Pu and Am during the evaluation period. The downstream locations associated with GS10 at the time are shown in Figure E-9; monitoring data for these locations are shown in Figures E-10 and E-11. Pu and Am 12-month averages at GS10 have remained below the RFLMA standards from mid-2014 through the end of this FYR period.

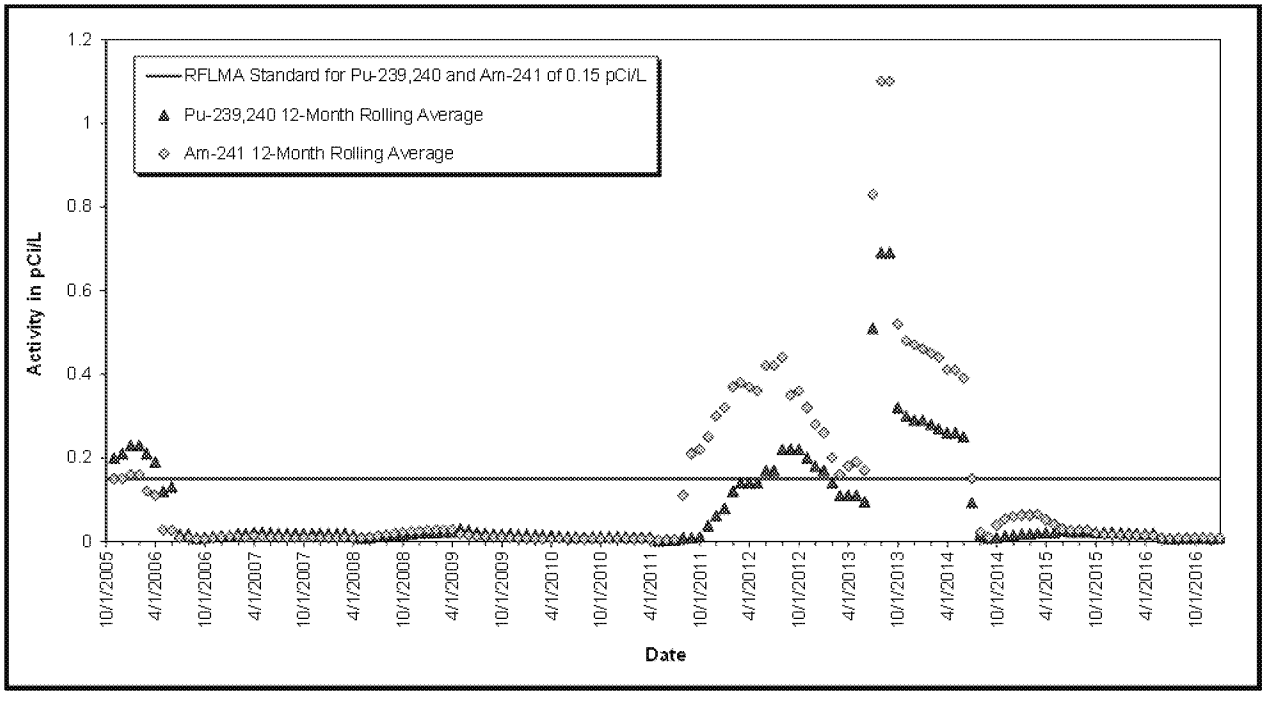
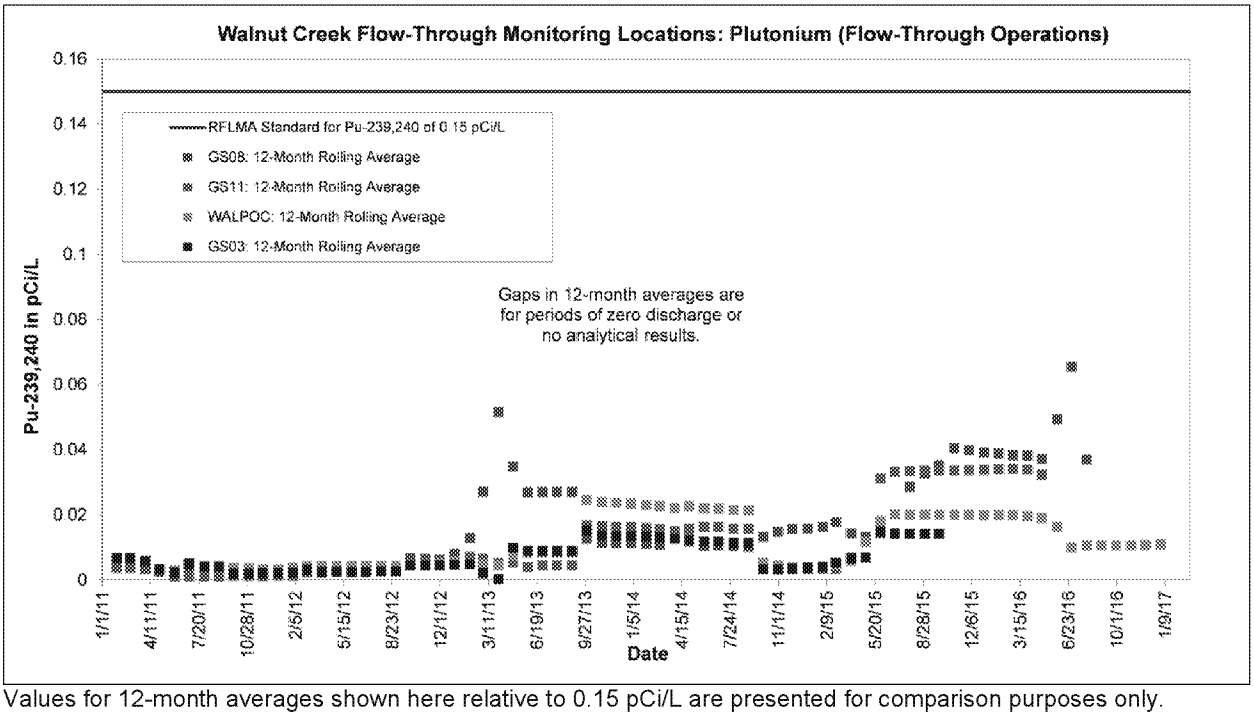


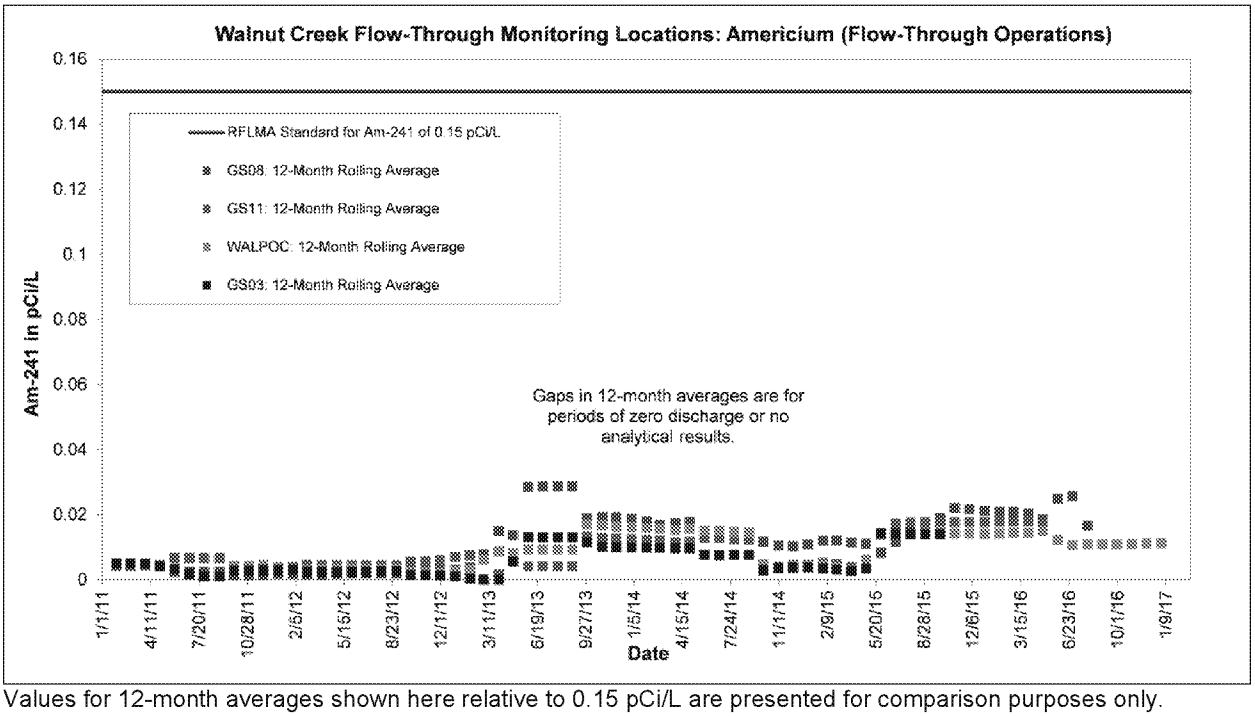

***Figure E-8. Volume-Weighted 12-Month Rolling Average Pu and Am Activities at GS10: Post-Closure Period***


*Figure E-9. GS10 and Associated Monitoring Locations*




Values for 12-month averages shown here relative to 0.15 pCi/L are presented for comparison purposes only.

***Figure E-10. Average Plutonium Activities at Locations Downstream of GS10***




Values for 12-month averages shown here relative to 0.15 pCi/L are presented for comparison purposes only.

***Figure E-11. Average Americium Activities at Locations Downstream of GS10***

### *1.2.1.2 SW027*

Surface water monitoring location SW027 is the POE at the eastern (downstream) end of the South Interceptor Ditch (SID), upstream of WOMPOC (Figure E-12). Figure E-13 presents the 12-month rolling average Pu and Am data for SW027 from site closure in 2005 through 2016.

The 12-month rolling average for Pu at SW027 (0.16 pCi/L) initially exceeded the RFLMA surface water standard of 0.15 pCi/L in April 2010 (CR 2010-06). Following consultation, mitigating actions were completed in December 2010 which included reseeding and installation of additional erosion controls in the SID drainage area (DOE/LM, 2010). These efforts were an attempt to reduce the movement of residual Pu in soil from the 903 Pad/Lip Area and into the SID. The 2006 RI/FS acknowledged that remaining concentrations of Pu in soil from this area, while below the soil cleanup action level, could result in the exceedance of surface water quality standards should Pu be transported through soil erosion (DOE/LM, 2010). Inspection of the area and evaluation of upstream and downstream data did not identify any new Pu source. The concentration of Pu during this timeframe at WOMPOC, downstream of SW027, did not exceed the RFLMA standard. Additional detail regarding evaluation of Pu at SW027 is found in the 2011 annual report (DOE 2012). No composite samples were collected at SW027 from October 2010 until February 2013, due to lack of surface water flow. All SW027 samples collected in 2013 were below the RFLMA standards for Am and Pu (Figure E-13); no composite samples

were collected in 2014 due to lack of flow. Location SW027 was dry until March 2015, when sampling resumed.

A reportable condition for Pu with a 12-month rolling average of 0.22 pCi/L was documented shortly after sampling resumed in April 2015 (CR 2015-05). The 12-month rolling average for Am subsequently exceeded the standard in June 2015. Following consultation, additional measures were implemented to enhance the vegetation and erosion controls implemented in 2010 and 2011. These measures were mostly completed by August 2015 and included the addition of erosion matting, wattles, berms and organic mulch in the SID drainage area; additional erosion matting in the SID was completed in March 2016. The 12-month rolling averages for Pu at SW027 continued to exceed the RFLMA standard through the end of this FYR period. Am continued to exceed the RFLMA standard until June 2016; since June 2016 and through the end of this FYR period Am was below the standard.

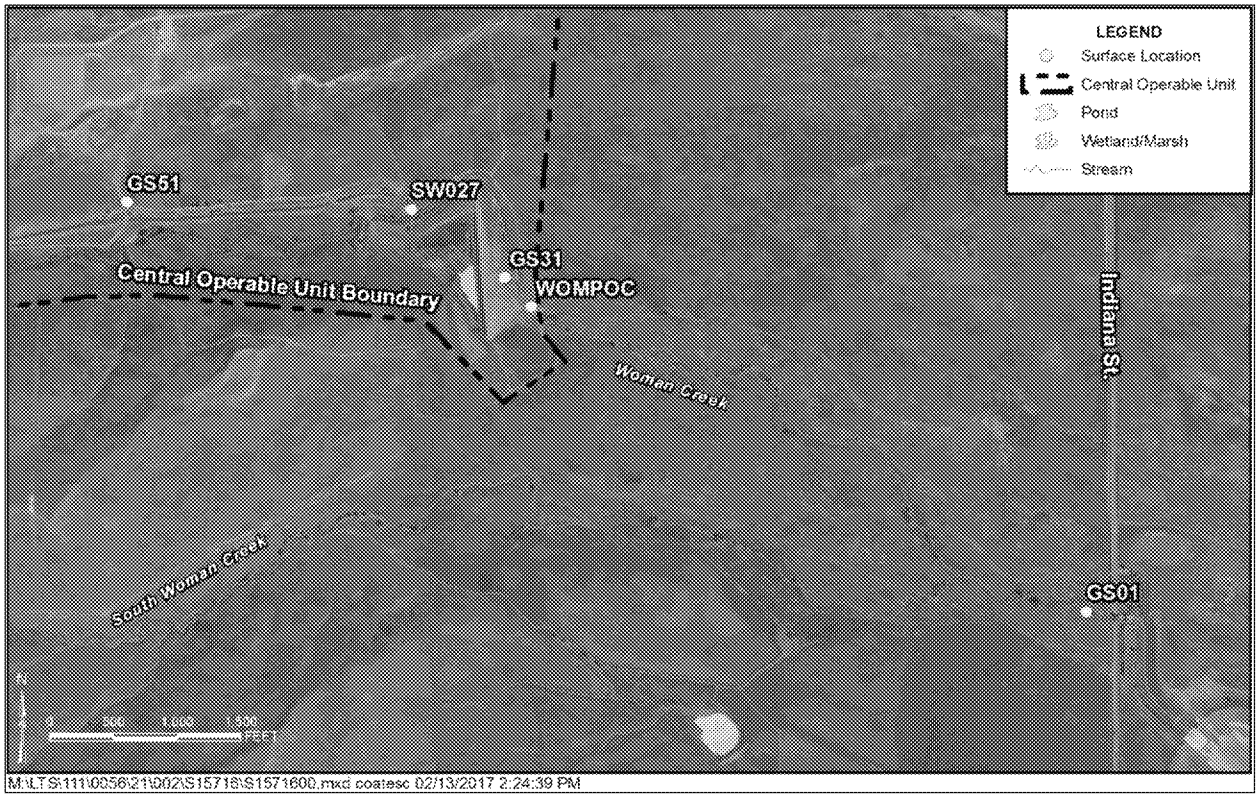



***Figure E-12. SW027 and Associated Monitoring Locations***

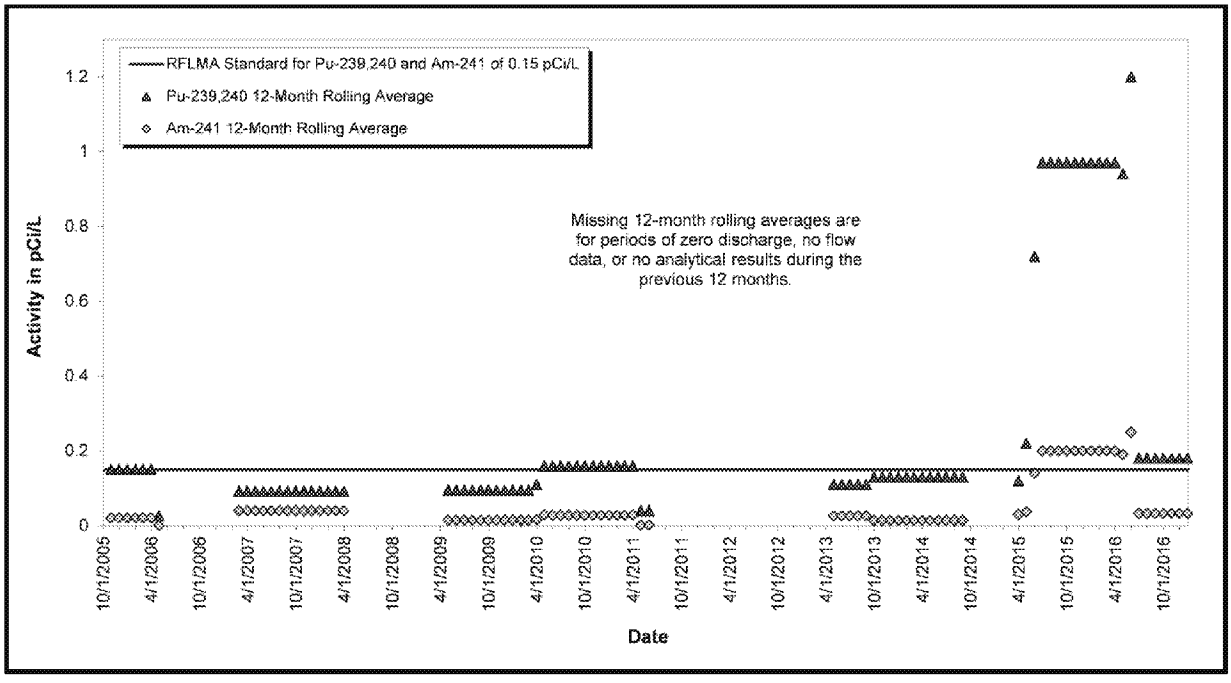



***Figure E-13. Volume-Weighted 12-Month Rolling Average Plutonium and Americium Activities at SW027: Post-Closure Period Ending CY 2016***

### 1.2.2 Performance Monitoring Locations

Performance monitoring locations are downstream of specific remedies (Figure E-2) and are used to determine the short- and long-term effectiveness of these remedies where known contaminants may affect surface water. The results of monitoring at these locations are discussed in the sections indicated below. There are currently six performance monitoring locations:

- NNG01, which monitors surface water downstream of the PLFTS (see Section 6.1.4.1)
- SW018, which monitors surface water in Functional Channel 2 (see Section 6.1)
- GS13, which monitors surface water downstream of the SPPTS (see Section E1.1.2.2)
- GS10, which monitors surface water downstream of the MSPTS (see Section E1.2.1.1)
- POM2, which monitors surface water downstream of the ETPTS (see Section E1.1.2.4)
- GS05, which monitors surface water upstream of the OLF (see Section 6.1.4.2)
- GS59, which monitors surface water downstream of the OLF (see Section 6.1.4.2)

# 2.0 References

U.S. Department of Energy, Office of Legacy Management, 2010. Letter from S.R. Surovchak, LM Site Manager to C. Spreng, RFLMA Project Coordinator, Regarding *Status Report of Steps Taken Regarding Monitoring Results at Surface Water Point of Evaluation (POE) SW027*, August 31.

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DOE (U.S. Department of Energy), 2015. *Rocky Flats Site Annual Report of Site Surveillance and Maintenance Activities, Calendar Year 2014*, April.

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